CITY OF PALOS VERDES ESTATES

DEPARTMENT OF
PUBLIC WORKS
(213) 375-0383

CITY HALL
PALOS VERDES ESTATES
CALIFORNIA 90274

NEGATIVE DECLARATION

CITY OF PALOS VERDES ESTATES, CALIFORNIA

GENERAL PLAN SEISMIC SAFETY ELEMENT

Project Description

This project consists of the adoption of the Seismic Safety Element of **the** General Plan of the City of Palos Verdes Estates, California as required **by the** State of California Government Code Section 65302

FINDINGS

In view of the fact that the conclusions of the Seismic Safety Element **do not** propose any adverse alterations to the environment as defined under **the** California Environmental Quality Act it is hereby determined that this **project** will not have a significant effect on the environment.

INITIAL STUDY

The initial study for this project is the first draft of the proposed **Seismic** Safety Element, prepared by George Taylor, Director of Public Works/ **Planning** Director of the City of Palos Verdes Estates in conjunction with **Dr.** Bernard W. Pipkin, Associate Professor Department of Geological Sciences, **University** of Southern California. Copies of the initial study can be obtained **from the** office of the Director of Public Works, 340 Palos Verdes Drive West, **Palos** Verdes Estates, California 90274.

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CITY OF PALOS VERDES ESTATES

SEISMIC SAFETY ELEMENT

OF THE GENERAL PLAN

Prepared and Submitted by: George C. Taylor
City Engineer and
Planning Director

in conjunction with

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Department of Geological
Sciences
University of Southern Californi

Approved by Planning Commission November 4, 1975

Approved by City Council December 9, 1975

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CITY OF PALOS VERDES ESTATES
INCORPORATED 1939
CALIFORNIA

CITY HALL
PALOS VERDES ESTATES
CALIFORNIA 90274

October 17, 1975

TO: Planning Commission

FROM: George Taylor, Public Works Director/City Engineer

SUBJECT: Seismic Safety Element

Enclosed is a copy of the subject element for your review.

Please note a public hearing on this element will be held at your meeting of November 4, 1975.

Should you have any questions please contact me.

Very truly yours,

George Taylor
Public Works Director/
City Engineer

GT/mm

cc: Dr. Pipkin w/copy
Public Works Director w/copy
Hee
Graf
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PREFACE

Shortly after six o'clock on the morning of February 9, 1971, between five and ten million residents of Southern California were awakened by the sudden and frightening shock of an earthquake. In ten seconds extensive damage was done to structures, mainly in the northern San Fernando Valley. Some of these structures collapsed, causing deaths and injuries, others were damaged to the verge of collapse, and many suffered costly, though non-hazardous, damage.

The earthquake centered near Pacoima Dam just northeast of the San Fernando Veterans Administration Hospital. In the northern San Fernando Valley the shaking was very intense; in central Los Angeles the shaking was strong, attenuating to rather weak shaking in Long Beach. It was fortunate that the earthquake was not of greater magnitude, for in that case a much greater area would have experienced very strong ground shaking and there would have been a much greater loss in life and property damage.

The earthquake had a Richter magnitude of 6.6, and the area deformed by the fault slip was about twelve to fifteen miles on a side. The effect was that an area of approximately 200 square miles in the San Gabriel Mountains moved southward and rose permanently several feet. In doing so it caused very strong ground shaking over this area and propagated ground-shaking waves, whose intensity decreased with distance, over a substantially larger area.

Fortunately, the San Fernando earthquake was not a great shock in geological terms. It released only one hundredth as much energy as the 1964 Alaska earthquake. In fact, shocks of energy-release comparable to the San Fernando earthquake occur about once every five years in Southern California, but they are seldom close to developed areas. The San Fernando earthquake caused a greater financial loss than the much larger Alaska earthquake because it occurred on the edge of a large metropolitan area instead of in a sparsely populated region.

Still, it was mainly good fortune that the fatalities were relatively few. Had the earthquake centered twenty miles farther south, close to the center of population in metropolitan Los Angeles, it would have done much more damage and caused the collapse of many more old buildings. Had it occurred three hours later in the day there would have been many more occupants in the buildings that did collapse. Had the freeways been crowded, the bridges that collapsed would have caused many more deaths and injuries, and other casualties would have resulted from automobile accidents caused by the sudden disruption of the thoroughfare. Had the earthquake occurred when more people were on downtown streets there would have been many more casualties from falling debris. Finally, the lower San Fernando Dam had only four feet of freeboard after its partial failure; had it then failed completely - or even after emptying was well along - an area inhabited by 80,000 people would have been inundated.

There is reasonable expectation that before the end of the century an earthquake of much greater magnitude will occur in Southern California. It can be expected to produce very strong shaking over the entire Los Angeles metropolitan area. This ground shaking probably will not exceed the intensity experienced in northern San Fernando Valley, but it may be almost as strong.

Most modern construction withstood strong ground shaking satisfactorily during the San Fernando earthquake, which shows that the metropolitan area can be made to survive a truly great earthquake if certain necessary improvements are made.

The earthquake did reveal certain weaknesses in engineering and construction practices, and in institutional and organizational arrangements. The Commission believes that these weaknesses can be corrected by appropriate improvements in safety regulations, in building codes and in preparations for an emergency. Even though the earthquake brought tragedy to some, if it leads to the correction of these weaknesses it will have brought a long-term benefit to all Southern Californians.

-- Report of the Los Angeles County
Earthquake Commission
SAN FERNANDO EARTHQUAKE
February 9, 1971

SEISMIC SAFETY ELEMENT

CITY OF PALOS VERDES ESTATES

INTRODUCTION

Authority of Seismic Safety Element

Section 65302 (f) of the Government Code of the State of California requires that each city prepare and adopt a seismic safety element of the city's general plan as follows:

> A seismic safety element consisting of an identification and appraisal of seismic hazards such as susceptibility to surface ruptures from faulting, to ground shaking, to ground failures, or to effects of seismically induced waves such as tsunamis and seiches.
>
> The seismic safety element shall also include an appraisal of mudslides, landslides, and slope stability as necessary geologic hazards that must be considered simultaneously with other hazards such as possible surface ruptures from faulting, ground shaking, ground failure and seismically induced waves.

In accordance with that section of the Government Code, the City of Palos Verdes Estates has prepared a seismic safety element which takes into consideration the specific geological and physical characteristics of Palos Verdes Estates, as well as the general characteristics from a seismological standpoint of the geographical area in which the city is located.

Background For The Element

The Urban Geology Master Plan prepared by the California Division of Mines and Geology in 1973 states that, if given a continuation of present conditions, it is estimated that losses due to earthquake shaking will total $21 billion in California between 1970 and the year 2000. That report also states that losses, especially life losses, due to shaking from future earthquakes can and should be reduced through a combination of measures involving geologic and seismologic research, engineering practices, building codes, urban planning and zoning, fiscal and taxation policies, and preparedness planning. Estimates of potential loss of life for this period range well up into the thousands.

The General Plan Guidelines of the California Council on Intergovernmental Relations issued in September 1973 points out the following information about earthquakes:

> The most widespread effect of an earthquake is ground shaking. This is usually (but not always) the greatest cause of damage. Structures of all types, including engineered structures and public utility facilities, if inadequately constructed or designed to withstand the shaking force, may suffer severe damage or collapse. The vast majority of deaths during earthquakes are the result of structural failure due to ground shaking. Most such deaths are preventable, even with present knowledge. New construction can and should be designed and built to withstand probable shaking without collapse. The greatest existing hazard in the State is the continued use of tens of thousands of older structures incapable of withstanding earthquake forces. Knowledge of earthquake-resistant design and construction has increased greatly in recent years, though much remains to be learned.

A second effect of earthquakes is ground failure in the form of landslides, rock falls, subsidence and other surface and near-surface ground movements. This is often the result of complete loss of strength of water-saturated sub-surface foundation soils ("Liquefaction"), such as occurred near the Juvenile Hall in the 1971 San Fernando earthquake, and in the massive Turnagain Arm landslide in Anchorage, during the 1964 Alaska earthquake. Most such hazardous sites can be either avoided or stabilized if adequate geologic and soil investigations are utilized.

Another damaging effect of earthquakes is ground displacement (surface rupture) along faults. Such displacement of the earth's crust may be vertical, horizontal or both and may offset the ground by as much as 30 feet (as in 1857 in Southern California). It is not economically feasible to design and build foundations of structures (dams, buildings, bridges, etc.) to remain intact across such zones. Fault zones subject to displacement are best avoided in construction. In addition to regional investigations necessary to the basic understanding of faults and their histories, detailed site investigations are needed prior to the approval of construction in any suspected active fault zone. Utilities, roads, canals and other linear features are particularly vulnerable to damage as the result of ground displacement.

Other damaging effects of earthquakes include tsunamis (seismic sea waves, often called "tidal waves"), such as the one which struck Crescent City and other coastal areas in 1964; and seiches (waves in lakes and reservoirs due to tilting or displacement of the bottom or margin). The failure of dams due to shaking, fault displacement or overtopping (from seiches or massive landsliding into the reservoir) can be particularly disastrous. Most modern dams are designed and constructed to be earthquake-resistant; some older dams were not. In addition to man-made dams, temporary dams may be created by earthquake-triggered landslides. Such inadvertently created dams are certain to fail within a relatively short time.

Injury, loss of life, and property damage resulting from earthquakes are not only caused by structural deficiencies but also by equipment, machinery, furniture, and other installations which happen to be located within a structure.

It should be recognized that the building of structures in the area of known geologic hazards involves an element of risk and that future construction must be in accordance with that risk. Consequently, Palos Verdes Estate's policies should be geared to the following definitions:

Acceptable Risk - The level of risk below which no specific action by local government is deemed to be necessary.

Unacceptable Risk - Level of risk above which specific action by government is deemed to be necessary to protect life and property.

Avoidable Risk - Risk not necessary to take because individual or public goals can be achieved at the same or less total "cost" by other means without taking the risk.

OBJECTIVES AND POLICIES

Goals and Objectives

The seismic safety goals and objectives of the City of Palos Verdes Estates are to develop and implement programs that will help to protect the lives and property of city residents by reducing seismic hazards.

The potential dangers created by seismic activity requires that it should be the basic goal of the City to:

1. Minimize injuries and the possible loss of life, disruption of public services, and damage to or destruction of property associated with major earthquakes.
2. Aid in the restoring of services to a level that enables the residents and businesses to return to normal activity as soon as possible after an earthquake.
3. Reduce the economic and social dislocations resulting from a major seismic event.

General Policies

In carrying out the general goals of Palos Verdes Estates and reaching the objectives for seismic safety it will be necessary for the City to:

1. Provide a base of seismic information that will require consideration of geologic hazards at the earliest possible point in the further development of the city.

2. Support a realistic disaster plan which would quickly become operational should the area be affected by a major earthquake or other type of disaster.

3. Minimize the number of existing structures and conditions that represent seismic hazards through enforcement of building codes.

4. Require geologic reports as a pre-requisite to the issuance of building permits for major structures.

5. Use geologic and seismic data to guide the placement and development of essential public structures such as schools, police and fire facilities, hospitals, and other types of critical installations.

6. Require consideration of geologic and seismic data in the preparation of environmental impact reports.

7. Inform the public of potential seismic hazards as they affect buildings and structures.

From the standpoint of man-made structures, exposure to earthquake hazards involves several factors:

1. Seismic nature of the site on which a structure is located.

2. Ability of a structure to resist earthquakes.

3. Use or occupancy of a structure, both as to number of occupants and amount of time occupied.

4. Effective life of a structure from a physical standpoint.

Emergency Operations for Earthquakes

After the San Fernando Earthquake of 1971, various governmental agencies, the American Red Cross, and non-governmental groups took effective measures to minimize the disastrous effects of the earthquake. Recovery was relatively rapid. However, weaknesses were noted in emergency operations. Some agencies performed independently at a time when team effort would have been of greater benefit. The need was shown for local agencies to provide emergency operating centers where information could be pooled and coordination achieved from a single, central location. Since disasters usually affect many local governments, provision should be made for interjurisdictional coordination and exchange of information in the event of an emergency.

Providing for seismic safety includes the development of a major earthquake response plan. Such a plan should:

1. Outline actions to be taken in earthquake situations.
2. Be coordinated with emergency plans of other governmental organizations - both local and county-wide.
3. Contain descriptive elements based upon local conditions such as:

a. Organization and training

b. Communications control

c. Fire protection

d. Water and other utility systems

e. Medical and hospital services

f. Transportation (if necessary)

The emergency plan should provide an organizational structure for dealing with any type of local emergency. It is a tool for use in case of a major earthquake, but it must be geared to function in any disaster. In preparing the EOP, the following response priorities should be considered:

1. Provide medical aid to the injured, protect the uninjured from hazards created by the earthquake, and provide for those people who are left homeless.
2. Restore community services as soon as possible, including utility services and the reopening of essential businesses.
3. Protect public and private property from further damage due to aftershocks, fire and looting.
4. Provide services to neighboring communities that also have been damaged and need assistance.
5. Facilitate post-disaster recovery throughout the community.

The City of Palos Verdes Estates Emergency Operations Plan as revised in February of 1974 provides such a plan.

GENERAL INFORMATION ON EARTHQUAKES

Faults and Seismicity

Seismic movements of the earth or earthquakes are caused by the sudden rupturing and displacement of the earth along faults (weak portions of the earth's crust). This rupturing relieves stress that has been building up in the earth's crust. It also is generally believed that this stress is caused by the movement of large plates that constitute the earth's crust. As these crustal plates move against or past one another, stress develops which causes the crust on the edge of each plate to become deformed. When too much deformation (elastic strain) builds up, the rocks snap along a fault. This relieves the strain by allowing each side of the fault to move to a position of lower stress, and transmits elastic waves in all directions.

A fault which separates two plates is not always perceivable on the earth's surface, but there are land forms and geologic criteria and instrumentation which can be used to map its location. The fault is not one solid, continuous line, but is composed of a system of splinter faults which appear periodically on the earth's surface. The term fault trace is used to describe a line on the surface of the earth formed by the intersection of the fault with the earth's surface.

Rupture and cracking of the ground are surface expressions of earthquakes which originate on subsurface faults. Earthquakes occur at various depths within the earth's crust. The point below the surface where the rupture first occurs is known as the focus and can be located with the help of seismic instruments. The term "epicenter" is usually used to describe the point of initial rupture directly over the focus. The instrumental epicenter is that point on the earth's surface directly above the focus but may not be the area of maximum damage.

There are two kinds of faults: active faults which have experienced displacement in recent geologic time, suggesting that future displacement can be expected on these faults; and inactive faults that have shown no evidence of movement in recent geologic time, suggesting that these faults are dormant. However, some faults labeled as inactive are so termed due to lack of historic data knowledge.

Geological Processes of Earthquakes

Earthquakes commonly give rise to various geological processes that may cause severe damage to structures and loss of life to people in them. These processes include surface rupture ground shaking, associated ground failure, generation of large waves in bodies of water, and regional subsidence. These seismic hazards vary widely from area to area, and the level of these hazards depends on both geologic conditions and the extent and type of land use. They are described below:

Surface Faulting. The earth's crust is laced with faults - - planes or surfaces in earth materials along which failure has occurred and materials on opposite sides have moved relative to one another in response to the accumulation of stress. Most of these faults have not moved for tens-of thousands of years and thus can be considered inactive. Others, however, show evidence of current activity or have moved sufficiently recently to be considered active, i.e., capable of displacement in the near future. A fault movement beneath a building in excess of an inch or two could have catastrophic effects on the structure, depending upon its design and construction and the shaking stresses it experiences at the same time.

Generally, faults are regarded as active and of concern to land-use planning when there is evidence that they have moved during historic time; or through geologic evidence, there may be a significant likelihood that they will move during the projected use of a particular structure or piece of land. Because geologic evidence may be lacking as to the times of past movement, geologists may be able to estimate relative degree of activity only after a regional analysis that may extend far beyond the locality under consideration. Such analysis may be based on historic evidence of fault movement, seismic activity (occurrence of small to moderate earthquakes along the fault trace even though not accompanied by obvious fault movement), displacement of

recent earth layers (those deposited during the past 10,000 years), an presence of topographical fault-produced features (scarps, sag ponds, offset stream courses and disruption of man-made features such as fences and curbs.)

Movement seldom is limited to a single fault surface throughout the lifetime of a fault system such as the San Andreas. In many places individual fault surfaces make up the San Andreas in a zone varying in width from a few hundreds to thousands of feet. Faults that commonly produce significant displacement (more than several inches at a time) often have related branches that diverge from the main fault but usually have less movement along them. They also may have secondary faults that are not directly or obviously connected physically to the main fault trace. Secondary faults are usually nearby (within hundreds of feet) of the main rupture, but they may extend as much as several miles away. As with branch faults, displacement along secondary faults is usually only a fraction of that along a main fault.

Ground Shaking. Probably the most difficult task today, in terms of the predictive capability of the geologist and seismologist, is devising a reasonably reliable method of predicting "ground shaking" effects - - what most people and structures react to during an earthquake. Examination of damage from numerous past earthquakes, in lieu of conclusive strong-motion seismograph records, has suggested to

geologists and engineers that the greatest damage to tall structures results where they are built over thick, relatively soft, water-saturated sediments and that the least damage occurs where they are built on very firm bedrock.

Ground Failure. Earth materials in a natural condition tend to reach equilibrium over a long period of time. In geologically active areas such as California and Alaska, there are many regions where earth materials have not yet reached a natural state of stability. For example, most of the valleys and bay margins are underlain by recent loose materials that have not been compacted and hardened by long-term natural processes. Landslides are common on most of the hills and mountains as loose material moves downslope. In addition, many activities of man tend to make the earth materials less stable and hence to increase the chance of ground failure. Some of the natural causes of instability are earthquakes, weak materials, stream and coastal erosion, and heavy rainfall. Human activities that contribute to instability include oversteepening of slopes by undercutting them or overloading them with artificial fill, extensive irrigation, poor drainage, resulting in subsidence, and removal of stabilizing vegetation. These causes of failure, which normally produce landslides and differential settlement, are augmented during earthquakes by strong ground motions that result in rapid changes in the state of earth materials. It is these changes, by means of liquefaction and loss of

strength in fine-grained materials, that result in so many landslides during earthquakes.

Results of Ground Failure. Although the basic causes of ground instability are simple in concept, the consequences are often complex and highly variable. They include numerous varieties of landslides, ground cracking, lurching, subsidence, and differential settlement. Moreover, these types of ground failure occur on a wide variety of ground conditions. Landslides, for example, do not necessarily require a steep slope on which to form, particularly during earthquakes. Many occur on slopes that are virtually flat, and the surface on which they fail may be very shallow (1 to 2 feet deep) or as much as hundreds of feet below the ground surface. The type of ground failure that develops in a given area is determined by the nature of the natural or man-made disturbance that occurs and partly by the topographic, geologic, hydrologic, and geotechnical characteristics of the ground.

Tsunami and Seiche Effects. Tsunami are large ocean waves which are generated by rapid changes in elevation of large masses of earth and water. Such rapid movement may generate huge waves of destructive force that can travel thousands of miles. During the 1964 Alaskan earthquake, for example, faulting and crustal warping created tsunami, or sea waves, tens of feet high that spread more than 1,500 miles from the source are and caused devastation to coastal communities within

their reach. The effects of tsunami can be greatly amplified by the configuration of the local shoreline and the sea bottom. Seiches are earthquake-generated waves within enclosed or restricted bodies of water (lakes, reservoirs, and bays).

How Earthquakes Are Measured

Vibrations produced by earthquakes are detected, recorded, and measured by instruments called seismographs. The zig-zag trace recorded by a seismograph - called a "seismogram" - reflects the varying amplitude of the vibrations by responding to the motion of the ground beneath the instrument. From the data expressed in seismograms, the time, epicenter, and focal depth of an earthquake can be determined, and estimates can be made of the amount of energy that was released.

The severity of an earthquake can be expressed in several ways. The magnitude of an earthquake, as expressed by the Richter magnitude scale, is measured by the amplitude of the seismic wave. The amplitude is measured on a seismogram of a standard seismograph. When the earth quakes, the amplitude of the wave recorded on the seismograph is measured and then is corrected mathematically to what the amplitude would have been if it had been recorded at a distance of 100 kilometers from the epicenter. The Richter magnitude derived from these corrected seismograph recordings indicates the amount of energy released as if it had been recorded at this standard 100-kilometer distance from the epicenter of the quake.

The intensity as expressed by the Modified Mercalli Intensity Scale, is mostly a subjective measure which depends on the effects of a quake such as damage at a particular location.

Richter Magnitude Scale. The Richter magnitude scale, named after Dr. Charles F. Richter, Professor Emeritus of the California Institute of Technology, measures the energy of an earthquake at its source, and is the scale most commonly used. On this scale, the earthquake's magnitude is expressed in whole numbers and decimals. However, Richter magnitudes can be confusing and misleading unless the mathematical basis for the scale is understood. It is important to recognize that magnitude varies logarithmically with the wave amplitude of the quake recorded by the seismograph. Each whole number step of magnitude on the scale represents an increase of 10 times in the measured wave amplitude of an earthquake, and an increase of 31 times in the amount of energy released by the quake. Thus, the amplitude of an 8.0 magnitude earthquake is not twice as large as a shock of magnitude 4.0, but 10,000 times as large. Correspondingly, a magnitude 8.0 earthquake releases almost one million times more energy than one of magnitude 4.0.

A quake of magnitude 2 on the Richter scale is the smallest quake normally felt by humans. Earthquakes with a Richter magnitude of 7 or more are commonly considered to be major. The Richter magnitude scale

has no fixed maximum or minimum; observations have placed the largest recorded earthquake in the world at about 8.9, and the smallest at about -3. Earthquakes with magnitudes smaller than 2 are called "microearthquakes." Richter magnitudes are not used to estimate damage. An earthquake in a densely populated area, which results in many deaths and considerable damage, may have the same magnitude as an earthquake that occurs in a barren, remote area, that may do nothing more than frighten the wildlife.

Modified Mercalli Intensity Scale of 1931 - The first scale to reflect earthquake intensities was developed by de Rossi of Italy and Forel of Switzerland in the 1880's. This scale, with values from I to X, was used for about two decades. A need for a more refined scale increased with the advancement of the science of seismology, and in 1902, the Italian seismologist, Mercalli, devised a new scale on a I to XII range. The Mercalli Scale was modified in 1931 by American seismologists Harry O. Wood and Frank Neumann to take into account modern structural features, and modified by Charles F. Richter in 1956 and rearranged:

I. Earthquake shaking not felt. But people may observe marginal effects of large distance earthquakes without identifying these effects as earthquake-caused. Among them: trees, structures, liquids, bodies of water sway slowly, or doors swing slowly.

II. Shaking felt by those at rest, especially if they are indoors, and by those on upper floors.

III. Felt by most people indoors. Some can estimate duration of shaking. But many may not recognize shaking of building as caused by an earthquake; the shaking is like that caused by the passing of light trucks.

IV. Hanging objects swing. Windows or doors rattle. Wooden walls and frames creak.

V. Felt by everyone indoors. Many estimate duration of shaking. But they still may not recognize it as caused by an earthquake. The shaking is like that caused by the passing of heavy trucks, though sometimes, instead, people may feel the sensation of a jolt, as if a heavy ball had struck the walls. Hanging objects swing. Standing autos rock. Crockery clashes, dishes rattle or glasses clink. Doors close, open or swing. Windows rattle.

VI. Felt by everyone indoors and by most people outdoors. Many now estimate not only the duration of shaking but also its direction and have no doubt as to its cause. Sleepers wakened. Hanging objects swing. Shutters or pictures move. Pendulum clocks stop, start or change rate. Standing autos rock. Crockery clashes, dishes rattle or glasses clink. Liquids disturbed, some spilled. Small unstable objects displaced or upset. Weak plaster and Masonry D* crack. Windows break. Doors close, open or swing.

VII. Felt by everyone. Many are frightened and run outdoors. People walk unsteadily. Small church or school bells ring. Pictures thrown off walls, knicknacks and books off shelves. Dishes or glasses broken. Furniture moved or overturned. Trees, bushes shaken visibly, or heard to rustle. Masonry D* damaged; some cracks in Masonry C*. Weak chimneys break at roof line. Plaster, loose bricks, stones, tiles, cornices, unbraced parapets and architectural ornaments fall. Concrete irrigation ditches damaged.

Modified Mercalli Intensity Scale of 1931 (Continued)

VIII. Difficult to stand. Shaking noticed by auto drivers. Waves on ponds; water turbid with mud. Small slides and caving in along sand or gravel banks. Large bells ring. Furniture broken. Hanging objects quiver. Masonry D* heavily damaged; Masonry C* damaged, partially collapses in some cases; some damage to Masonry B*, none to Masonry A*. Stucco and some masonry walls fall. Chimneys, factory stacks, monuments, towers, elevated tanks twist or fall. Frame houses moved on foundations if not bolted down; loose panel walls thrown out. Decayed piling broken off.

IX. General fright. People thrown to ground. Changes in flow or temperature of springs and wells. Cracks in wet ground and on steep slopes. Steering of autos affected. Branches broken from trees. Masonry D* destroyed; Masonry C* heavily damaged, sometimes with complete collapse; Masonry B* is seriously damaged. General damage to foundations. Frame structures, if not bolted, shifted off foundations. Frames racked. Reservoirs seriously damaged. Underground pipes broken.

X. General panic. Conspicuous cracks in ground. In areas of soft ground, sand is ejected through holes and piles up into a small crater, and, in muddy areas, water fountains are formed. Most masonry and frame structures destroyed along with their foundations. Some well-built wooden structures and bridges destroyed. Serious damage to dams, dikes and embankments. Railroads bent slightly.

XI. General panic. Large landslides. Water thrown on banks of canals, rivers, lakes, etc. Sand and mud shifted horizontally on beaches and flat land. General destruction of buildings. Underground pipelines completely out of service. Railroads bent greatly.

XII. General panic. Conspicuous cracks in ground. In areas of soft ground, sand is ejected through holes and piles up into a small crater, and, in muddy areas, water fountains are formed. Damage nearly total, the ultimate catastrophe. Large rock masses displaced. Lines of sight and level distorted. Objects thrown into air.

*Masonry A: Good workmanship and mortar, reinforced, designed to resist lateral forces.
Masonry B: Good workmanship and mortar, reinforced.
Masonry C: Good workmanship and mortar, unreinforced.
Masonry D: Poor workmanship and mortar and weak materials, like adobe.

Source: Urban Geology Master Plan

TECHNICAL FINDINGS OF THE SEISMIC SAFETY ELEMENT

Geologic Setting.

The Palos Verdes Hills are within the greater geological province known as the Los Angeles Basin. The entire southern California area is seismically active and there are several active faults in the Basin in close proximity to Palos Verdes Estates (Fig.1). The Newport-Inglewood fault is the closest major active fault and was the one responsible for the damaging Long Beach earthquake of 1933. The peninsula proper is bounded by two active faults on the north and south sides (Fig.2). The Palos Verdes Fault on the north side does not break through to the ground surface and is manifest by steeply dipping upper Pleistocene sands and gravels. The fault on the south side lies offshore and is inferred to exist along the steep slopes of the San Pedro Escarpment that leads down into the depths of the San Pedro Basin at 3,000 feet below sea level. Most of the active faults of the L. A. Basin exist in deeply buried granitic or metamorphic basement rocks and movement at depth has caused anticlines or domal structures to form in the thick overlying pile of sedimentary rock. Within the basin the overlying rocks attain a thickness of up to 16,000 feet, whereas on the Palos Verdes Peninsula they are much thinner and estimated to be about 2,000 feet thick. In contrast, the San Andreas fault 50 miles to the east, and the San Gabriel frontal fault system that caused the disastrous Sylmar earthquake of 1971, are known to have surface rupture.

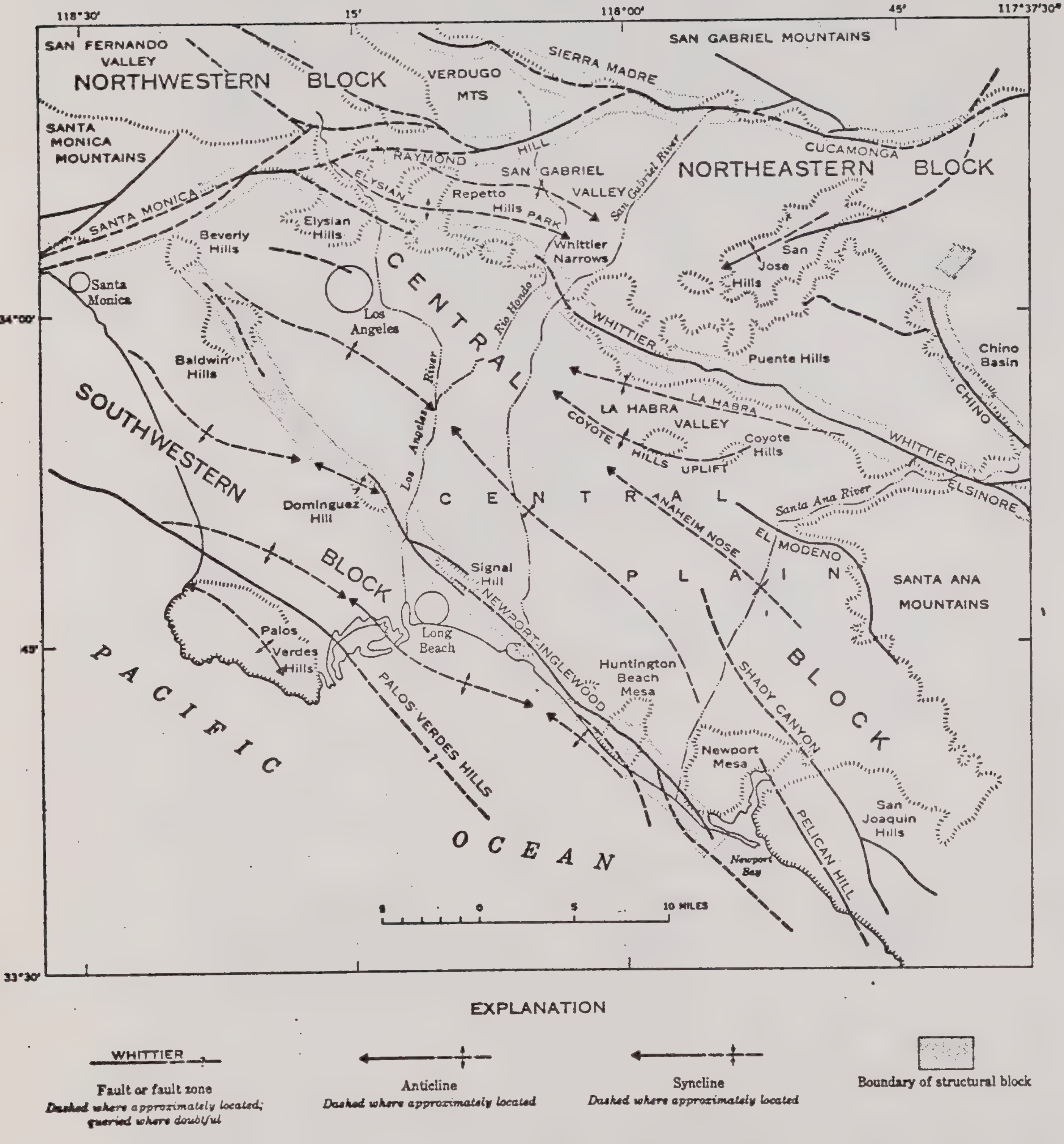

Figure 1. Major geographic and structural features of basement rock in the Los Angeles Basin (after Yerkes and others, 1965)

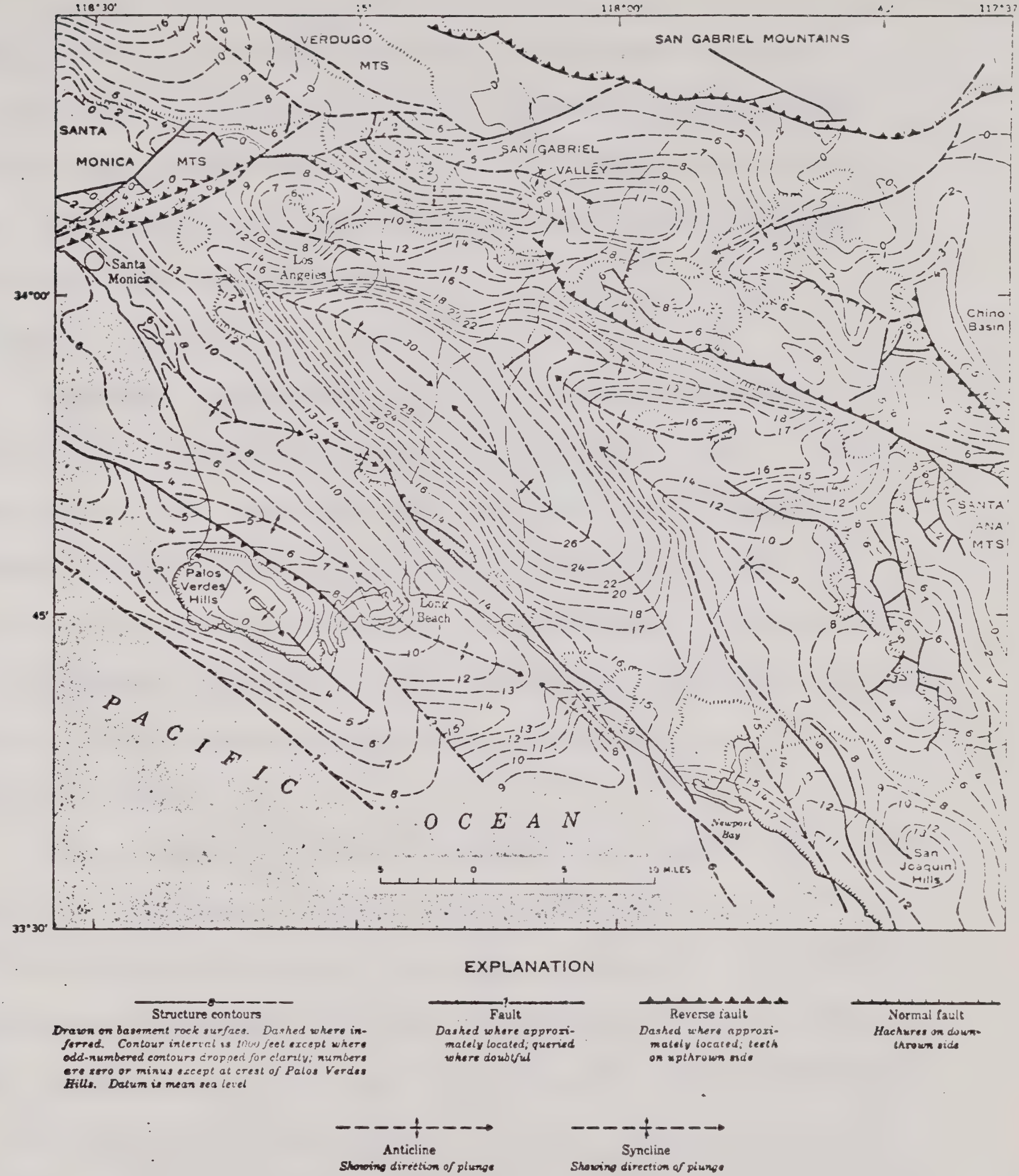

Figure 2. Major faults, structural features, and contours on basement rock, L.A. Basin (after Yerkes and others, 1965

This fact has far-reaching consequence on the accelerations and surface intensity to be expected from movements along these faults. Much greater damage can be expected where surface rupture occurs than where movement is at depth and the overlying rocks subjected to bending and lesser fracturing.

Geological Materials.

The Palos Verdes Hills consist of a basement or foundation rock of Jurassic to Cretaceous age known as the Catalina Schist. Draped over these ancient rocks are found up to 2,000 feet of marine sedimentary rocks that vary from Miocene to Pleistocene in age. The greatest area of Palos Verdes Estates is underlain by Miocene shales of the Monterey Formation. Smaller areas are supported by Pleistocene marine terrace deposits and sand dune material (Fig. 3).

Seismic History.

Table I contains a listing of earthquakes of magnitude 4.0 and over within a 50 kilometer (30 mile) radius of Palos Verdes Estates, 33°45'N, 118°20'W) as provided by the Seismological Laboratory at the California Institute of Technology. It is quite obvious that with the exception of the primary shock of the Long Beach earthquake of 1933 (Richter Magnitude 6.3) and a few aftershocks of that event, there have been no major events in the region. The 1933 event caused damage to a significant degree (VII+ on the Modified Mercalli Scale) in a region of 450 square miles from Manhattan Beach to Laguna Beach, California

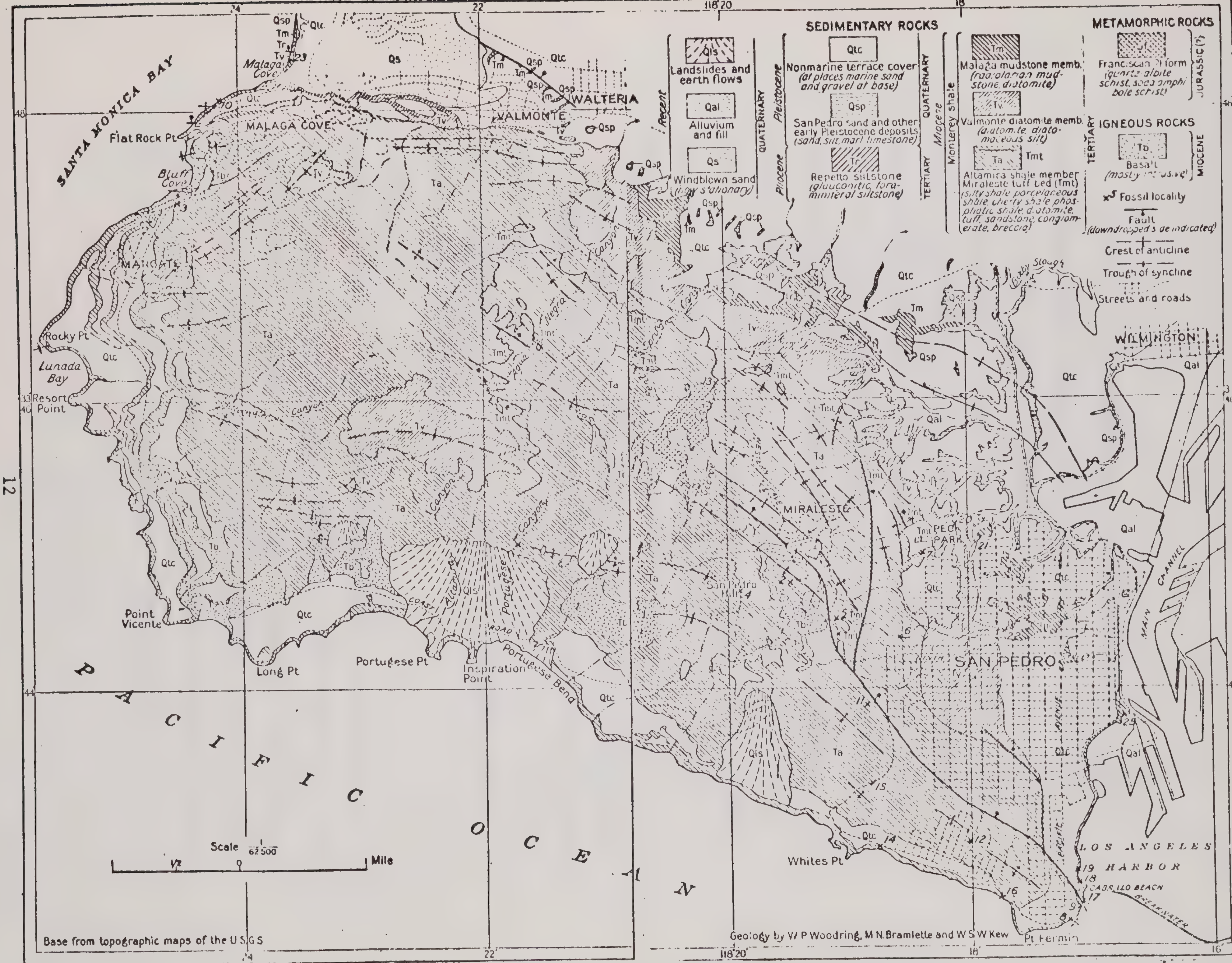

Fig. 3. Geologic map of Palos Verdes Hills(after Woodring, et. al., 1936)

12

(Wood, 1933). No accurate estimate of ground shaking was possible for the Palos Verdes Estates area as it was sparsely populated, however, according to Wood (1933), "...Inside the area mentioned there are many places where significant damage was not conspicuous--on hilly ground or where underground conditions were not unfavorable and construction not too bad or unsuitable. This was noticeably the case on the compact sedimentary rocks of the San Pedro Hills west of Long Beach. In fact, a considerable part of the area appeared to be characterized by intensity lower than grade VII of the 1931 scale." Richter (1959) notes "On the principally Tertiary block of the San Pedro Hills intensity was barely VI, contrasting sharply with serious damage nearby in San Pedro and Long Beach."

An intensity of VI was assigned to the Palos Verdes Estates area as a result of the Sylmar shock of February 9, 1971 that had a Richter Magnitude of 6.4 (U.S. Geological Survey, 1971). In other words, the two major earthquakes in the area in the last half century have produced only minor (slight) damage.

Seismic Hazards

Ground rupture. The Palos Verdes fault trends in a northwesterly direction and lies several hundred yards northeast of Palos Verdes Estates (Fig. 2). The fault does not displace surface rocks, rather, it is manifest by a sharp downbending of Pleistocene deposits along the norheast edge of the hills. Subsurface data from deep wells and gravity profiles indicate the fault lies outside the study area and displaces older base —

Fig. 4. Microregionalization map of Los Angeles Basin and vicinity(after Richter, 1959)

ment rock at depth, however, it only arches the younger overlying sedimentary rocks. Many low-magnitude earthquakes have been centered along the fault, yet no surface rupture has ever been reported.

Shaking. In his attempt to characterize ground response to the greatest expectable earthquake throughout southern California and the state, Richter (1959) has assigned an intensity of VII (modified Mercalli Scale) to most of the City of Palos Verdes Estates (Fig. 4). He assigned these ratings as follows: Intensity VII, Tertiary sediments and volcanics as are found over most of the Peninsula (Fig. 3); Intensity VIII, to consolidated Quaternary deposits; and an Intensity IX, to Quaternary stream deposits, sand dunes, and landslide areas. On the north side of Palos Verdes Estates there is a small area underlain by consolidated Quaternary deposits (Figs. 3 and 4), whereas the remainder of the city is underlain by Tertiary sedimentary rocks. In Palos Verdes Estates the younger Quaternary deposits are so thin that it is anticipated that only a slight additional response to seismic waves will be felt in these areas. Drill data and surface exposures indicate that the younger sands attain a thickness of 30 feet along the cliffs near the Pacific Ocean, and that they thin toward the north and east from there.

Tsunami. The only record of a local earthquake having caused a sea wave of large magnitude was in connection with the earthquake of December 21, 1812. This is to be found in mission records and it was reported that a ship was carried up the canyon at Refugio Beach north of Santa Barbara, then back out to sea (Byerly, in

State of California, 1964). The entire shoreline of the City of Palos Verdes Estates is backed by sea cliffs from 100 to 200 feet high, and even if a tsunami were generated no seismic sea wave could ever top these heights. There is no tsunami risk in the area.

Ground failure. Permanent disruption or settlement of foundation materials may be caused by liquefaction of poorly consolidated sand or clay soils. Liquefaction of unconsolidated sands may occur where they are of a critical grain size and water saturated. Quaternary sands (ancient dune sands) underlying the northern part of the study area are coarse-grained and cohesive. Where exposed along seacliffs at Malaga Cove they stand in near-vertical slopes. Minor seepage has been noted locally at the contact of the sands and underlying diatomaceous shale. However, this flow is intermittent and not indicative of a saturated sand body as is required for liquefaction.

So-called "quick" clays collapse when subject to artificial or natural vibrations. These deposits are characteristically of glacial-marine sedimentary origin and not known to exist at the surface or subsurface on the Peninsula.

Associated Geologic Hazards.

Landslides. Mass wasting, that is, the downslope movement of rock and soil must be considered simultaneously with direct seismic effects. Falls and slides can be triggered by earthquake motion on steep slopes, as a rule those greater than 2:1 (about 28°). On the Palos Verdes Peninsula large slides have occurred along bedding planes in the Altamira Shale and are strictly a local phenomenon.

Slump or rotational failures are restricted to shallow depths within the soil profile and are not considered serious hazards. Rock falls have been reported along the seacliffs in the study area and could be a problem under seismic loads where adverse geologic structures exist. Large Translational failures (block glides) along bedding planes are known on the Peninsula but have not occurred in the study area.

In order to assess the risk from these hazards maps were prepared derivitive from the U.S. Geological survey topographic and geologic ones. The derivitive maps (see appendices) show slope angles and earth materials in the study area. Shown on the maps are slopes steeper than 2:1 (greatest susceptibility to failure during a quake). 2:1 to 5:1 (low susceptibility), and slopes less than 5:1 (essentially no risk). Rock and soil types at or just beneath the surface are also shown. The relative susceptibility of each to ground shaking and sliding is as follows:

Quaternary Terrace Cover(Qtc) - - deposits on raised marine terrace surfaces. Usually a thin or non-existent sand layer covered by adobe soil. The adobe cover varies in thickness from a foot to as much as twenty feet. Where tha terrace cover is thick, a greater response to seismic waves may be expected. Slopes are less than 5:1 therefore no landslide risk.

Quaternary Sand Dunes (Qs) - - Consolidated and cohesive sand of variable thickness, but at least 30-feet thick in the northwest part of the study area. Terrain underlain by this soil would be most responsive to seismic waves. Occurs in areas of low slope angles thus little landslide potential.

Valmonte Diatomite (Tv) - - Small outcrop area of diatomaceous shale along seacliffs in the northwest portion of the city. This rock has a high resistance to downslope movement, however, along cliffed areas some failures have occurred due to groundwater seepage. Some lurching effects can be expected during a strong earthquake.

Altamira Shale (Ta) - - Usually thin adobe soils overlying competent siliceous and diatomaceous shales with relatively low response to seismic shaking. Where local adverse geologic conditions exist it may be slide prone.

Tertiary Basalt (Tb) - - Resistant bedrock type not prone to sliding and with a low response to seismic waves. This material acts to buttress slopes and the cliffed points along the Peninsula shoreline.

Along seacliff areas, where there is a thick terrace or sand-dune cover, lurching effects would be the greatest hazard due to ground motion. This could result in ground cracking and slumping along the cliffs during shaking. Such sites are delineated on the map (Exhibit A), most notably the Malga Cove-Bluff Cove section.

Bedrock along the cliffs is expected to perform well during an earthquake. Some falling of loose joint blocks and detached rocks will occur, but gross failure is not anticipated. Preliminary geotechnical investigation is required for each building site along the cliffs reducing risks to a minimum. A few sites have already been designated as marginal and would require extensive ground modification before approval for building.

<u>Assessment</u>.

Palos Verdes Estates is a small suburban residential community

with an area of 4.75 square miles. It is bounded on the northeast by the Palos Verdes fault and lies in a region of high seismicity in Southern California. The largest local quake in historic times was a Magnitude 6.2 on March 10, 1933, centered near Long Beach. Shaking effects on the Peninsula ranged from Intensity VII (modified Mercalli Scale) in areas underlain by Tertiary sedimentary rocks, to Intensity VIII where consolidated younger terrace and dune-sand deposits occur. No surface rupture due to faulting has ever occurred on the Peninsula, and the known active faults in the region lie outside the study area.

Shaking will cause slight damage to well-built structures, whereas considerable damage may be expected in older and/or poorly built structures. Inasmuch as 98± percent of the buildings in the city are one and two-story single-family dwellings of modern construction, little serious damage due to shaking is expected. Older structures may sustain considerable damage. There are 34 one, two, and three-story multiple dwellings clustered about the Malaga Cove and Lunada Bay commercial centers. These are modern wood, stucco, and brick construction and would sustain damage similar to well built single-family dwellings.

Surficial slumps of soil and weathered bedrock can be expected on slopes steeper than 2:1 during strong motion. Dwellings founded on piers or caissons in bedrock will not be affected by slumping, however, older structures with shallow continuous footings on steep slopes may sustain considerable structural damage. Large translation failures (block glides) are not known in Palos Verdes

Estates, although massive failures of this type have occurred at Portuguese Bend (Merriam, 1960) and Point Fermin. The adverse geologic conditions and rock types leading to this type of failure have not been found within the city, but they may exist in currently undeveloped land or city-owned parklands.

Damage or loss of life from seiche, tsunami, and mudslide is considered negligible, although access to city-owned beaches should be restricted should an earthquake centered offshore occur.

Mitigating Measures.

The City of Palos Verdes Estates has implemented the following plans and regulations which individually and collectively provide for control of the level of risk that may occur due to seismic related hazards.

1. An emergency operations plan.
2. A two and one half story building height restriction.
3. A Grading Ordinance which requires individual review and preparation of an environmental impact analysis on any development that:
   a. Requires removal of major native vegetation.
   b. Results in a combined cut and fill grading in excess of 250 cubic yards.
   c. The Building Official believes there is need for an Engineering Geology Report or Soils Engineering Report .
4. A requirement that all building plans be signed by a licensed architect unless the value of a new building is less than $8,000.00 or the value of an addition, alteration or repair is less than $4,000.00 or the project does not involve any architectural

4. (cont.)

design or structural engineering.

5. An Ordinance which adopts the 1973 addition of the Uniform Building Code prepared and published by the International Conference of Building Officials.

LAND USE AND CIRCULATION

The land use and related circulation development in Palos Verdes Estates is single family residential except in the Lunada Bay and Malaga Cove commercial centers. These patterns are set by deed restriction in addition to the City's land use and zoning regulations. In view of this, future development of the City is limited to single family residents and upgrading or replacement of existing multi-family and commercial buildings.

By normal processing of new building permits and remodeling and reconstruction permits, building code requirements are met and structures are required to comply with current design standards for seismic occurrences.

SEISMIC SAFETY ELEMENT RELATIONSHIPS

Relationship to the General Plan

This mandatory element of the Palos Verdes Estates General Plan reflects the statewide concern for seismic safety planning. Palos Verdes Estates General Plan is two years old, and it is considered as complete and in need of no revisions. The Circulation Element and the Land Use Element are parts of the original document adopted in 1973. The City also has adopted the Housing Element, Safety Element, Noise Element and the Open Space-Conservation Element of the General Plan as required by State law. This Seismic Safety Element is closely related to the Safety Element and forms the basis for all building permit evaluations.

The City-wide limitation of a two and one half story building height acts as a positive factor in reducing the percentage of casualties in the event of a major quake along the Newport-Inglewood system or great quake along the San Andreas system.

Environmental Impact Report Procedures

It is appropriate and desirable that the City require that a comprehensive environmental impact report be prepared on all significant projects that deal with new buildings or zone changes that provide for intensification of land use. A development's ability to withstand potential natural disaster should play an important part in the findings in such a report.

IMPLEMENTATION AND REVIEW

Building Inspection Program

A continuing building inspection program has been followed throughout the years of Palos Verdes Estates'existence. Due to the nature of the improvements within the City, it has not been necessary to follow an extensive building inspection program with particular reference to seismic safety. However, in the future, major construction or developments should be required to conform to seismic safety in accordance with contemporary standards. It has been found that pre-1933 buildings used lime motor for joints, poor quality bricks, inadequate structural ties connecting roofs and walls, and no reinforcing steel in the walls. Any high risk structure in Palos Verdes Estates should be located and identified. It if is economically feasible to do so, such a structure should be strengthened and modernized. In some cases, it may be more appropriate to reduce the load level or occupancy of the structure. As a last resort, any building which cannot be rehabilitated and is literally unsafe should be demolished.

Contingency Plans for Major Disasters and Emergencies

In cooperation with Civil Defense Area G of Region I (Los Angeles County) of the California Office of Emergency Services, the City of Palos Verdes Estates has prepared an Emergency Operation Plan (EOP). This plan provides for preparing, mobilizing and employing public and private resources to meet essential needs in serious emergencies. This plan can be placed in effect when a state of war emergency exists in the State of California, when a state of emergency affecting Palos Verdes Estates is

declared by the Governor, or in case of local emergency by action of the City Government.

The City of Palos Verdes Estates also has a Mutual Aid and Joint Powers Agreement with the twelve other cities located within operational Area G of Civil Defense Region I of California. This agreement provides that it is necessary and desirable that the resources, personnel, equipment and facilities of any one part to the agreement be made available to any other party to prevent, combat, or eliminate a probable imminent, or actual threat to life or property resulting from a local peril, local emergency, local disaster, or civil disturbance, in the absence of a duly proclaimed "state of extreme emergency" or "state of disaster", and to render mutual and supplementary police protection one to the other as the need may arise.

Seismic and Emergency Information Programs

Study and experience have shown that the public generally does not know what to do before, during, or after a major earthquake. Due to the unpredictability of earthquakes and the potential violence and destruction in their wake, some individuals fail to prepare properly, and therefore react irrationally.

The public should be made aware of the relative seismic safety hazards of Palos Verdes Estates and its geographical area. Consequently, the City should develop and implement an emergency information and education program to provide the public with timely instructions that will enable the residents to prepare for and safely respond to the effects of a major earthquake or other type of disaster or emergency. This should include information about the nature of earthquakes and why Southern California is subject to seismic occurrences.

The local schools, churches and civic organizations should be encouraged and aided to the extent practicable, to provide disaster training for school children and others. This should include information and advice on how to protect themselves, their families, and their homes during and after a major earthquake or other emergency.

Building Code Update

The City of Palos Verdes Estates operates under the International Conference of Building Officials Building Code which has been adopted by reference with some local modifications. Prior to adoption by the City Council, the Building Code and its amendments are submitted for thorough review by the construction industry and various professional organizations.

In cooperation with the ICBO, steps should be taken to provide the necessary building regulations to insure the stability of major new buildings in case of significant seismic events. Conversely, the

City should be aware of the changes made by the ICBO in the Uniform Building Code to increase the seismic safety of various kinds of structures, and they should be adopted for appropriate use in Palos Verdes Estates.

CONCLUSIONS AND RECOMMENDATIONS

Based upon the data developed during this study for the Seismic Safety Element of the General Plan of the City of Palos Verdes Estates, the following comments, conclusions and recommendations are submitted for consideration and action:

1. No earthquake faults are known to directly underlie the City of Palos Verdes Estates,

   However, some branches of the Palos Verdes Fault may not have been located and geologic surveillance should continue as areas near the zone are more fully developed.

2. Palos Verdes Estates is generally free of any possible damage due to the following phenomina: Ground rupture, Tsunami, liquefaction, large translational failures (Block Glides), Seiche and mudslides.
3. The greatest predictable earthquake throught Southern California could result in an intensity of VIII on the modified mercalli scale in a limited area of Palos Verdes Estates with the

majority of the City having an intensity of VII.

4. 4. The only areas that could expect major damage due to ground shaking are the older structures.

5. In the areas of the City where Altamira Shale or Valmonte Diatomite outcroppings occur along the seacliffs, special efforts should be made to eliminate and prevent groundwater seepage.

6. Preliminary geotechnical investigations should continue to be required on any building site located along the seacliffs, and in addition on any lot with a slope equal to or steeper than two feet horizontal to one foot vertical.

7. The upgrading of building and safety codes for new construction from a seismic safety standpoint should be aimed at lessening loss of life or serious injury. Any increased protection above this level should be at the option of the owner of the property. However, property owners should be encouraged to take the steps necessary to protect their properties against the economic risks of seismic hazards.

8. Pre-1933 buildings in Southern California constitute the most serious threat to public safety because of the probability of their collapse during strong earthquakes in the future. By normal remodeling and reconstruction permits, building code requirements are met and structures are required to comply with current design standards for seismic occurrences.

9. Structures and facilities which are particularly important in post-disaster operations, such as emergency power installations, emergency operating centers, public safety facilities and essential elements of key communications systems, should be designed and constructed to withstand strong earthquake shaking and to continue to function.

10. All public schools are required by state law to conform to very rigid seismic safety design. In addition the Field Act requires that any non-complying structure be brought up to standard. The schools in Palos Verdes Estates are all subject to these requirements and have complied with them.

11. Most typical, modern, one-story, wood-frame houses perform well during eartquake ground shaking in that no severe hazards are created nor are major economic losses widespread in such structures.

12. Utility companies serving or within Palos Verdes Estates should consider the effects of significant seismic events in the planning, design, construction and operations of their installations. To the extent practicable, they should provide spares or redundancies in separated locations, and they should develop repair and recovery ability for emergencies including standby capability. In general, the features of the various systems which are the most vulnerable to

12. seismic disturbances should be identified, and steps should be taken to have the utility companies minimize potential adverse effects. For example valves should be installed at strategic locations for shutoff and isolation of a section of a system. Interconnections of systems for safety are desirable even though they may be limited in capacity.

13. Public safety and welfare depend greatly on the functioning of public utility systems, such as water supply, sewers, gas, electricity, communications and transportation. Consequently, continuing attention should be given to insure that these faciltities will not be seriously disrupted during an earthquake. Public utilities are, in general, such complicated systems that special studies should be made on how adequate earthquake resistance can best be achieved at an economical cost. The State of California probably should take the lead in initiating and sponsoring such research.

14. There are no major highway structures, overpasses, bridges, or tunnels within the City of Palos Verdes Estates, which would be vulnerable to landslides, liquefaction or other geologic hazards.

15. Adequate fire protection should be an integral part of the planning for seismic safety. This includes provisions for an adquate water supply, both from the standpoint of an effective distribution system and a standby source of water on an emergency basis. Also, zoning practices should insure that future developments

adequately provide for the manipulation and deployment of firefighting equipment, particularly in the residential areas of the City.

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TABLES

AND

APPENDICES

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DEFINITIONS OF TERMS

Accelerograph

An instrument for measuring accelerations or for detecting and measuring vibrations.

Aftershock

Aftershocks are a part of the release of accumulated elastic strain. When a significant earthquake occurs, it not only relieves the pressure along its particular section of fault but also changes the stress patterns for miles around. These changes, in turn, create adjustments of their own.

California Emergency Services Act

The California Emergency Services Act, Chapter 7 of Division 1 of Title 2 of the Government Code, is that portion of the State Code that provides the legal basis for the preparation of emergency plans and the conduct of emergency operations by the State of California and its political subdivisions.

Emergency Operating Center (EOC)

An emergency operating center is a facility designed and equipped to provide a site for local government executives and key officials to direct and control emergency operations. When constructed to Federal criteria, it provides protection against fallout radiation (100 protection factor) and includes a communications center, emergency power, fuel, food and water for a fourteen-day period.

Emergency Operations

Emergency operations refer to those measures and actions taken by local governments and their departments and agencies to minimize loss of life and property and to mitigate hardship resulting from disaster and to expedite recovery.

Epicenter

The part of the earth's surface directly above the point where the fault slip began.

Fault

A fracture of the earth's crust accompanied by a displacement of one side of the fracture with respect to the other.

Active Fault

A fault that has moved in recent geologic time and which is likely to move again in the relatively near future. (For geologic purposes, there are no precise limits to recency of movement or probable future movement that define an "active fault". Definitions for planning purposes extend on the order of 10,000 years or more back and 100 years or more forward. The exact time limits for planning purposes are usually defined in relation to contemplated uses and structures.)

Inactive Fault

A fault which shows no evidence of movement in recent geologic time and no evidence of potential movement in the relatively near future.

Field Act

A statute (Education Code, Sections 15451-15465), enacted following the Long Beach earthquake of 1933, that gave the State Division of Architecture authority and responsibility for approving design and supervising construction of public schools and establishing severe penalties for violations.

Foreshock

Minor movements along faults that sometimes precede and may even provide part of the triggering device for a main earthquake shock. They can occur weeks or months in advance, and their foci or hypocenters may be somewhat removed from that of the main movement.

Ground Deformation

Visible manifestation of earth movement along a fault, or earth cracking. Such movement may have been vertical or horizontal, or both.

Modified Mercalli Scale

A system that describes the effects (intensity) of an earthquake at specified points in terms of a series of levels ranging from I to XII. These intensities tend to be highest near the epicenter of the earthquake, decreasing with increasing distance from a central area; but often this is much modified by the nature of the ground.

Richter Scale

The Richter Magnitude Scale measures the magnitude of an earthquake. Earthquake magnitude numbers are used to compare differenct earthquakes independently of the locations of their epicenters or points of observations. They are calculated from measurements of seismograph records.

Riley Act

Health and Safety Code, Division 13, Part 3, Chapter 2, (Sections 19100-19170, which was enacted in 1933 following the Long Beach earthquake. The act established minimum State standards for construction and exempted farm buildings and dwellings occupied by not more than two families outside the limits of incorporated areas.

Scarp

A line of cliffs produced by faulting or erosion.

Seiches

Earthquake-induced standing waves in lakes or ponds.

Seismic Sea Waves (Tsunami)

Ocean waves, created by submarine earthquakes, that travel great distances at high speeds (average 450 mph) and have a high destructive potential depending on a number of factors such as shoreline configuration and depth of water. They are commonly referred to as tidal waves.

Seismograph

An instrument that writes a continuous record of the successive earth waves generated by an earthquake.

Soil Liquefaction

Change of water saturated cohesionless soil to liquid, usually from intense ground shaking; soil loses all strength.

Strong Shaking

That degree of shaking produced by the earth waves that are generated by an earthquake and radiate out from the hypocenter which is sufficient to cause substantial damage to structures of any size.

Tectonic

Of or relating to the deformation of the earth's crust; the forces involved in or producing such deformation, and the resulting forms. Movement may be rapid resulting in an earthquake, or slow (tectonic creep).

Uniform Building Code

The Uniform Building Code of the International Conference of Building Officials, which was written and adopted initially by the members of the conference in 1926 and as repeatedly amended. Though "uniform" in appearance, it recognizes special requirements of individual areas and so provides.

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The accompanying list is compiled from the USCoast and Geodetic Survey "Earthquake History of the United States, Part II, Stronger Earthquakes of California and Western Nevada," and yearly publications, "United States Earthquakes;" Gutenberg and Richter, "Seismicity of the Earth," and the publications of Caltech Seismological Laboratory.

Where the month is blank, the time of year is known only roughly, and the day is of no significance.

Time of day (24 hours, midnight to midnight) is given where known. PST

LAT and LONG are the latitude and longitude of the epicenter where it is known or inferred from the available reports of distribution of intensity; otherwise, the coordinates of the area of highest reported intensity.

Q indicates the presumed accuracy of LAT and LONG:

3 instrumental location good within 15 km.
4 listed to the nearest $\frac{1}{4}$ or 0.1 degree
5 listed to the nearest $\frac{1}{2}$ degree
6 listed to the nearest degree

MAG is magnitude on the Richter scale

I is maximum reported intensity on the Modified Mercalli Scale of 1931

A indicates estimated area of perceptibility:

1 1,000 - 2,999 square miles
2 3,000 - 9,999
3 10,000 - 29,999
4 30,000 - 99,999
5 100,000 - 299,999
6 300,000 or over

special reports take precedence over the above:
8 seismic sea wave
9 surface faulting is indicated or confirmed by descriptions of ground fissures

D distance in kilometers from the point designated by LAT and LONG to 33° 45' N, 118° 20' W

STRONG EARTHQUAKES NEAR 33°45'N 118°20'W (PALOS VERDES REGION)

YEAR	MO	DA	H M	LAT	LONG	Q MAG	I A	D
1812	12	8	.07..00..00.00	33..30.00	117..40.00	4..0.0..	8.5..	68
1855	7	10	.20..15..00.00	34..00.00	118..30.00	5..0.0..	8.0..8	32
1878		1	.00..00..00.00	34..00.00	118..30.00	5..0.0..	7.2..	32
1889	8	27	.18..15..00.00	34..00.00	118..00.00	6..0.0..	6.0..	41
1890	2	9	.04..06..00.00	34..00.00	117..30.00	5..0.0..	6.0..	82
1893	4	4	.11..40..00.00	34..30.00	118..30.00	5..0.0..	8.5..9	85
1903	12	25	.09..45..00.00	34..00.00	118..00.00	5..0.0..	6.0..	41
1910	5	15	.07..47..00.00	33..30.00	117..30.00	5..6.0..	7.0..	82
1912	12	14	.00..00..00.00	34..00.00	119..00.00	5..0.0..	6.5..	67
1918	4	22	.13..15..00.00	34..00.00	117..30.00	5..0.0..	6.0..	82
1918	11	19	.12..18..00.00	34..00.00	118..30.00	4..0.0..	6.0..	32
1920	6	21	.18..48..00.00	34..00.00	118..30.00	5..4.9..	8.0..3	32
1920	7	16	.10..08..00.00	34..00.00	118..30.00	5..0.0..	6.0..	32
1927	8	4	.04..24..00.00	34..00.00	118..30.00	5..0.0..	6.0..	32
1929	7	8	.08..46..00.00	34..00.00	118..00.00	4..4.7..	8.0..	41
1930	8	30	.16..40..00.00	33..00.00	118..00.00	5..5.2..	7.0..3	89
1933	3	10	.17..54..00.00	33..36.00	118..00.00	4..6.2..	9.0..5	35
1933	10	2	.01..10..00.00	33..48.00	118..06.00	3..5.4..	6.0..2	22
1938	5	31	.00..33..00.00	33..42.00	117..30.00	4..5.5..	6.0..4	77
1939	12	27	.11..28..00.00	33..48.00	118..06.00	4..4.5..	6.0..	22
1940	10	10	.21..57..00.00	33..48.00	118..24.00	4..5.0..	6.0..3	8
1941	11	14	.00..41..00.00	33..48.00	118..12.00	4..5.4..	7.5..2	13
1944	6	18	.16..03..00.00	33..54.00	118..12.00	4..4.5..	6.0..3	21
1952	8	23	.02..09..00.00	34..30.00	118..12.00	4..5.0..	6.0..4	84
1956	1	2	.16..25..00.00	33..48.00	117..30.00	4..4.7..	6.0..2	77
1956	2	6	.18..17..00.00	34..36.00	118..36.00	..4.2..	6.0..2	97
1956	2	6	.19..16..00.00	34..36.00	118..36.00	..4.6..	6.0..2	97
1957	3	18	.10..56..00.00	34..06.00	119..12.00	4..4.7..	6.0..2	89
1961	10	20	.11..49..00.00	33..39.00	118..00.00	3..4.3..	6.0..1	33
1965	1	1	.00..04..00.00	34..00.00	117..36.00	3..4.5..	6.0..2	73
1965	4	15	.12..08..00.00	34..06.00	117..30.00	3..4.5..	6.0..2	86
1965	7	15	.23..46..00.00	34..24.00	118..36.00	3..4.5..	6.0..2	76
1965	11	12	.15..55..00.00	34..00.00	118..12.00	3..3.0..	6.0..	30
1966	10	1	.21..12..00.00	33..58.00	118..19.00	3..3.5..	6.0..	24
1967	6	14	.20..58..00.00	34..00.00	117..58.00	3..4.1..	6.0..	44

CALIFORNIA INSTITUTE OF TECHNOLOGY
SEISMOLOGICAL LABORATORY, 295 NORTH SAN RAFAEL AVENUE, PASADENA, CALIFORNIA

MAILING ADDRESS:
P.O. BIN 2—ARROYO ANNEX
PASADENA, CALIFORNIA 91109

The accompanying list is extracted from a catalog of earthquakes recorded at the Seismological Laboratory, Pasadena, California, and its auxiliary stations.

Double periods replace colons in origin times, latitude and longitude; and separate quality from magnitude, and depth of focus from list identifiers.

Q — quality of epicenter location
- 1 unusually accurate
- 2 accurate within 5 km.
- 3 accurate within 15 km.
- 4 rough

MAG — magnitude on the Richter scale

DEPTH -- depth of focus in kilometers below sea level,
If LIST is 8 or 9, depth was assumed to be 15 km. in solving for epicenter

LIST — identifies source of epicenter determination:

- 9 Local Earthquake Bulletin 1934-1957, issued by the Seismological Laboratory and edited and revised by Clarence Allen and Pierre St. Amand
- 8 Local Earthquake Bulletin 1957 -- June, 1961, and later shocks not located by the method of least squares
- 7 locations determined by the U.S. Coast and Geodetic Survey: origin time reported to the nearest second, coordinates to the nearest tenth of a degree
- 1 locations obtained at the Seismological Laboratory, Pasadena, using the method of least squares on an electronic computer.

D — distance in kilometers from a specified point in the region; given only if the list is confined to shocks within a circle about that point.

For further details, see Nordquist, "A catalog of Southern California earthquakes, and associated data processing programs" Bulletin of the Seismological Society of America, vol. 54, pp 100[illegible] 1011 (reprint 480).

Time is Greenwich Mean Time -- for Pacific Standard Time, subtract 8 hours, for Pacific Daylight Time, subtract 7 hours.

EARTHQUAKES MAGNITUDE 4.0 AND OVER WITHIN 50 KILOMETERS OF 33°45'N 118°20'W
(PALOS VERDES AREA)

YEAR	MO	DA	H M S	° ' N	° ' W	Q MAG	DEPTH LIST	D
1933	3	11	.01..54..07.80	33..37.00	117..58.00	1..6.3..	.0..8	[illegible]
1933	3	11	.02..04..00.00	33..45.00	118..05.00	3..4.9..	.0..8	23
1933	3	11	.02..05..00.00	33..45.00	118..05.00	3..4.3..	.0..8	23
1933	3	11	.02..09..00.00	33..45.00	118..05.00	3..5.0..	.0..8	23
1933	3	11	.02..10..00.00	33..45.00	118..05.00	3..4.6..	.0..8	23
1933	3	11	.02..11..00.00	33..45.00	118..05.00	3..4.4..	.0..8	23
1933	3	11	.02..16..00.00	33..45.00	118..05.00	3..4.8..	.0..8	23
1933	3	11	.02..17..00.00	33..36.00	118..00.00	5..4.5..	.0..8	35
1933	3	11	.02..22..00.00	33..45.00	118..05.00	3..4.0..	.0..8	23
1933	3	11	.02..27..00.00	33..45.00	118..05.00	3..4.6..	.0..8	23
1933	3	11	.02..30..00.00	33..45.00	118..05.00	3..5.1..	.0..8	23
1933	3	11	.02..31..00.00	33..36.00	118..00.00	5..4.4..	.0..8	35
1933	3	11	.02..52..00.00	33..45.00	118..05.00	3..4.0..	.0..8	23
1933	3	11	.02..57..00.00	33..45.00	118..05.00	3..4.2..	.0..8	23
1933	3	11	.02..58..00.00	33..45.00	118..05.00	3..4.0..	.0..8	23
1933	3	11	.02..59..00.00	33..45.00	118..05.00	3..4.6..	.0..8	23
1933	3	11	.03..05..00.00	33..45.00	118..05.00	3..4.2..	.0..8	23
1933	3	11	.03..09..00.00	33..45.00	118..05.00	3..4.4..	.0..8	23
1933	3	11	.03..11..00.00	33..45.00	118..05.00	3..4.2..	.0..8	23
1933	3	11	.03..23..00.00	33..36.00	118..00.00	5..4.2..	.0..8	35
1933	3	11	.03..23..00.00	33..45.00	118..05.00	3..5.0..	.0..8	23
1933	3	11	.03..36..00.00	33..45.00	118..05.00	3..4.0..	.0..8	23
1933	3	11	.03..39..00.00	33..45.00	118..05.00	3..4.0..	.0..8	23
1933	3	11	.03..47..00.00	33..45.00	118..05.00	3..4.1..	.0..8	23
1933	3	11	.04..36..00.00	33..45.00	118..05.00	3..4.6..	.0..8	23
1933	3	11	.04..39..00.00	33..45.00	118..05.00	3..4.9..	.0..8	23
1933	3	11	.04..40..00.00	33..45.00	118..05.00	3..4.7..	.0..8	23
1933	3	11	.05..10..22.00	33..42.00	118..04.00	3..5.1..	.0..8	25
1933	3	11	.05..13..00.00	33..45.00	118..05.00	3..4.7..	.0..8	23
1933	3	11	.05..15..00.00	33..45.00	118..05.00	3..4.0..	.0..8	23
1933	3	11	.05..18..04.00	33..34.50	117..59.00	3..5.2..	.0..8	38
1933	3	11	.05..21..00.00	33..45.00	118..05.00	3..4.4..	.0..8	23
1933	3	11	.05..24..00.00	33..45.00	118..05.00	3..4.2..	.0..8	23
1933	3	11	.05..53..00.00	33..45.00	118..05.00	3..4.0..	.0..8	23
1933	3	11	.05..55..00.00	33..45.00	118..05.00	3..4.0..	.0..8	23
1933	3	11	.06..11..00.00	33..45.00	118..05.00	3..4.4..	.0..8	23
1933	3	11	.06..18..00.00	33..45.00	118..05.00	3..4.2..	.0..8	23
1933	3	11	.06..29..00.00	33..51.00	118..16.00	3..4.4..	.0..8	13
1933	3	11	.06..35..00.00	33..45.00	118..05.00	3..4.2..	.0..8	23
1933	3	11	.06..58..03.00	33..41.00	118..03.00	3..5.5..	.0..8	27
1933	3	11	.07..51..00.00	33..45.00	118..05.00	3..4.2..	.0..8	23
1933	3	11	.07..59..00.00	33..45.00	118..05.00	3..4.1..	.0..8	23
1933	3	11	.08..08..00.00	33..45.00	118..05.00	3..4.5..	.0..8	23
1933	3	11	.08..32..00.00	33..45.00	118..05.00	3..4.2..	.0..8	23
1933	3	11	.08..37..00.00	33..45.00	118..05.00	3..4.0..	.0..8	23
1933	3	11	.08..54..57.00	33..42.00	118..04.00	3..5.1..	.0..8	25
1933	3	11	.09..10..00.00	33..45.00	118..05.00	3..5.1..	.0..8	23
1933	3	11	.09..11..00.00	33..45.00	118..05.00	3..4.4..	.0..8	23
1933	3	11	.09..26..00.00	33..45.00	118..05.00	3..4.1..	.0..8	23
1933	3	11	.10..25..00.00	33..45.00	118..05.00	3..4.0..	.0..8	23
1933	3	11	.10..45..00.00	33..45.00	118..05.00	3..4.0..	.0..8	23
1933	3	11	.11..00..00.00	33..45.00	118..05.00	3..4.0..	.0..8	23
1933	3	11	.11..04..00.00	33..45.00	118..08.00	3..4.6..	.0..8	18
1933	3	11	.11..29..00.00	33..45.00	118..05.00	3..4.0..	.0..8	23

YEAR	MO	DA	H M S	° ' N	° ' W	Q MAG	DEPTH LIST	D
1933	3	11	.11..38..00.00	33..45.00	118..05.00	3..4.0..	.0..8	23
1933	3	11	.11..41..00.00	33..45.00	118..05.00	3..4.2..	.0..8	23
1933	3	11	.11..47..00.00	33..45.00	118..05.00	3..4.4..	.0..8	23
1933	3	11	.12..50..00.00	33..41.00	118..03.00	3..4.4..	.0..8	27
1933	3	11	.13..50..00.00	33..44.00	118..06.00	3..4.4..	.0..8	22
1933	3	11	.13..57..00.00	33..45.00	118..05.00	3..4.0..	.0..8	23
1933	3	11	.14..25..00.00	33..51.00	118..16.00	3..5.0..	.0..8	13
1933	3	11	.14..47..00.00	33..44.00	118..06.00	3..4.4..	.0..8	22
1933	3	11	.14..57..00.00	33..53.00	118..19.00	3..4.9..	.0..8	15
1933	3	11	.15..09..00.00	33..44.00	118..06.00	3..4.4..	.0..8	22
1933	3	11	.15..47..00.00	33..45.00	118..05.00	3..4.0..	.0..8	23
1933	3	11	.16..53..00.00	33..45.00	118..05.00	3..4.8..	.0..8	23
1933	3	11	.19..44..00.00	33..45.00	118..05.00	3..4.0..	.0..8	23
1933	3	11	.19..56..00.00	33..45.00	118..05.00	3..4.2..	.0..8	23
1933	3	11	.22..00..00.00	33..45.00	118..05.00	3..4.4..	.0..8	23
1933	3	11	.22..31..00.00	33..45.00	118..05.00	3..4.4..	.0..8	23
1933	3	11	.22..32..00.00	33..45.00	118..05.00	3..4.1..	.0..8	23
1933	3	11	.22..40..00.00	33..45.00	118..05.00	3..4.4..	.0..8	23
1933	3	11	.23..05..00.00	33..45.00	118..05.00	3..4.2..	.0..8	23
1933	3	12	.00..27..00.00	33..45.00	118..05.00	3..4.4..	.0..8	23
1933	3	12	.00..34..00.00	33..45.00	118..05.00	3..4.0..	.0..8	23
1933	3	12	.04..48..00.00	33..45.00	118..05.00	3..4.0..	.0..8	23
1933	3	12	.05..46..00.00	33..45.00	118..05.00	3..4.4..	.0..8	23
1933	3	12	.06..01..00.00	33..45.00	118..05.00	3..4.2..	.0..6	23
1933	3	12	.06..16..00.00	33..45.00	118..05.00	3..4.6..	.0..8	23
1933	3	12	.07..40..00.00	33..45.00	118..05.00	3..4.2..	.0..8	23
1933	3	12	.08..35..00.00	33..45.00	118..05.00	3..4.2..	.0..8	23
1933	3	12	.15..02..00.00	33..45.00	118..05.00	3..4.2..	.0..8	23
1933	3	12	.16..51..00.00	33..45.00	118..05.00	3..4.0..	.0..8	23
1933	3	12	.17..38..00.00	33..45.00	118..05.00	3..4.5..	.0..8	23
1933	3	12	.18..25..00.00	33..45.00	118..05.00	3..4.1..	.0..8	23
1933	3	12	.21..28..00.00	33..45.00	118..05.00	3..4.1..	.0..8	23
1933	3	12	.23..54..00.00	33..45.00	118..05.00	3..4.5..	.0..8	23
1933	3	13	.03..43..00.00	33..45.00	118..05.00	3..4.1..	.0..8	23
1933	3	13	.04..32..00.00	33..45.00	118..05.00	3..4.7..	.0..8	23
1933	3	13	.06..17..00.00	33..45.00	118..05.00	3..4.0..	.0..8	23
1933	3	13	.13..18..28.00	33..45.00	118..05.00	3..5.3..	.0..8	23
1933	3	13	.15..32..00.00	33..45.00	118..05.00	3..4.1..	.0..8	23
1933	3	13	.19..29..00.00	33..45.00	118..05.00	3..4.2..	.0..8	23
1933	3	14	.00..36..00.00	33..45.00	118..05.00	3..4.2..	.0..8	23
1933	3	14	.12..19..00.00	33..45.00	118..05.00	3..4.5..	.0..8	23
1933	3	14	.19..01..50.00	33..37.00	118..01.00	3..5.1..	.0..8	33
1933	3	14	.22..42..00.00	33..45.00	118..05.00	3..4.1..	.0..8	23
1933	3	15	.02..08..00.00	33..45.00	118..05.00	3..4.1..	.0..8	23
1933	3	15	.04..32..00.00	33..45.00	118..05.00	3..4.1..	.0..8	23
1933	3	15	.05..40..00.00	33..45.00	118..05.00	3..4.2..	.0..8	23
1933	3	15	.11..13..32.00	33..37.00	118..01.00	3..4.9..	.0..8	33
1933	3	16	.14..56..00.00	33..45.00	118..05.00	3..4.0..	.0..8	23
1933	3	16	.15..29..00.00	33..45.00	118..05.00	3..4.2..	.0..8	23
1933	3	16	.15..30..00.00	33..45.00	118..05.00	3..4.1..	.0..8	23
1933	3	17	.16..51..00.00	33..45.00	118..05.00	3..4.1..	.0..8	23
1933	3	18	.20..52..00.00	33..45.00	118..05.00	3..4.2..	.0..8	23
1933	3	19	.21..23..00.00	33..45.00	118..05.00	3..4.2..	.0..8	23

YEAR	MO	DA	H M S	° ' N	° ' W	Q MAG	DEPTH	LIST D
1933	3	20	.13..58..00.00	33..45.00	118..05.00	3..4.1..	.0..8	23
1933	3	21	.03..26..00.00	33..45.00	118..05.00	3..4.1..	.0..8	23
1933	3	23	.08..40..00.00	33..45.00	118..05.00	3..4.1..	.0..8	23
1933	3	23	.18..31..00.00	33..45.00	118..05.00	3..4.1..	.0..8	23
1933	3	25	.13..46..00.00	33..45.00	118..05.00	3..4.1..	.0..8	23
1933	3	30	.12..25..00.00	33..45.00	118..05.00	3..4.4..	.0..8	23
1933	3	31	.10..49..00.00	33..45.00	118..05.00	3..4.1..	.0..8	23
1933	4	1	.06..42..00.00	33..45.00	118..05.00	3..4.2..	.0..8	23
1933	4	2	.08..00..00.00	33..45.00	118..05.00	3..4.0..	.0..8	23
1933	4	2	.15..36..00.00	33..45.00	118..05.00	3..4.0..	.0..8	23
1933	5	16	.20..58..55.00	33..45.00	118..10.00	3..4.0..	.0..8	15
1933	8	4	.04..17..48.00	33..45.00	118..11.00	3..4.0..	.0..8	14
1933	10	2	.09..10..17.60	33..47.00	118..08.00	1..5.4..	.0..8	19
1933	10	2	.13..26..01.00	33..37.00	118..01.00	3..4.0..	.0..8	33
1933	10	25	.07..00..46.00	33..57.00	118..08.00	3..4.3..	.0..8	29
1933	11	13	.21..28..00.00	33..52.00	118..12.00	3..4.0..	.0..8	18
1933	11	20	.10..32..00.00	33..47.00	118..08.00	2..4.0..	.0..8	19
1934	1	20	.21..17..00.00	33..37.00	118..07.00	2..4.5..	.0..9	25
1934	4	17	.18..33..00.00	33..34.00	117..59.00	3..4.0..	.0..9	38
1934	10	17	.09..38..00.00	33..38.00	118..24.00	2..4.0..	.0..9	14
1934	11	16	.21..26..00.00	33..45.00	118..00.00	2..4.0..	.0..9	31
1935	12	25	.17..15..00.00	33..36.00	118..01.00	2..4.5..	.0..9	34
1936	8	22	.05..21..00.00	33..46.00	117..49.00	2..4.0..	.0..9	48
1936	10	29	.22..35..00.00	33..43.00	118..42.00	3..4.0..	.0..9	34
1937	1	15	.18..35..00.00	33..30.00	118..15.00	2..4.0..	.0..9	29
1937	7	7	.11..12..00.00	33..34.00	117..59.00	2..4.0..	.0..9	38
1938	5	21	.09..44..00.00	33..37.00	118..02.00	2..4.0..	.0..9	31
1938	8	31	.03..18..00.00	33..48.00	118..14.00	2..4.5..	.0..9	11
1938	11	29	.19..21..00.00	33..53.00	118..28.00	2..4.0..	.0..9	19
1938	12	7	.03..38..00.00	34..00.00	118..25.00	2..4.0..	.0..9	29
1939	11	4	.21..41..00.00	33..46.00	118..07.00	2..4.0..	.0..9	20
1939	12	27	.19..28..49.00	33..47.00	118..08.00	2..4.5..	.0..9	19
1940	1	13	.07..49..00.00	33..47.00	118..08.00	2..4.0..	.0..9	19
1940	2	8	.16..56..17.00	33..42.00	118..04.00	2..4.0..	.0..9	25
1940	2	11	.19..24..10.00	33..59.00	118..18.00	2..4.0..	.0..9	26
1940	7	18	.04..01..13.00	33..42.00	118..04.00	2..4.0..	.0..9	25
1940	10	11	.05..57..13.00	33..47.00	118..25.00	2..5.0..	.0..9	9
1940	10	12	.00..24..00.00	33..47.00	118..25.00	2..4.0..	.0..9	9
1940	10	14	.20..51..11.00	33..47.00	118..25.00	2..4.0..	.0..9	9
1940	11	1	.07..25..03.00	33..47.00	118..25.00	2..4.0..	.0..9	9
1940	11	1	.20..00..46.00	33..38.00	118..12.00	2..4.0..	.0..9	18
1940	11	2	.02..58..26.00	33..47.00	118..25.00	2..4.0..	.0..9	9
1941	1	30	.01..34..47.00	33..58.00	118..03.00	1..4.0..	.0..9	35
1941	3	22	.08..22..40.00	33..31.00	118..06.00	2..4.0..	.0..9	34
1941	10	22	.06..57..18.00	33..49.00	118..13.00	1..5.0..	.0..9	13
1941	10	22	.10..32..20.00	33..47.00	118..12.00	2..4.0..	.0..9	13
1941	11	14	.08..41..36.00	33..47.00	118..15.00	1..5.5..	.0..9	9
1942	4	16	.07..28..00.00	33..22.00	118..09.00	3..4.0..	.0..9	46
1944	6	19	.00..03..33.00	33..52.00	118..13.00	2..4.5..	.0..9	17
1944	6	19	.03..06..07.00	33..52.00	118..13.00	3..4.4..	.0..9	17
1950	1	11	.21..41..35.00	33..57.00	118..12.00	2..4.1..	.0..9	25
1961	10	20	.19..49..50.50	33..39.24	117..59.65	2..4.3..	4.6..1	33
1961	10	20	.20..07..14.46	33..39.57	117..58.84	2..4.0..	6.1..1	34

YEAR	MO	DA	H M S	° ' N	° ' W	Q MAG	DEPTH LIST	D
1961	10	20	.21..42..40.74	33..39.91	117..58.77	2..4.0..	7.2..1	34
1961	10	20	.22..35..34.21	33..40.29	118..00.75	2..4.1..	5.6..1	31
1961	11	20	.08..53..34.66	33..40.83	117..59.57	2..4.0..	4.4..1	32
1963	9	14	.03..51..16.24	33..32.56	118..20.41	2..4.2..	2.2..1	23
1967	1	8	.07..37..30.40	33..37.93	118..28.03	2..4.0..	11.4..1	18
1967	1	8	.07..38..05.34	33..39.79	118..24.80	3..4.0..	17.7..1	12
1967	6	15	.04..58..05.52	33..59.79	117..58.49	2..4.1..	10.0..1	43